AV-8908

Zoology B.Sc –Third Semester
LZC-301 (Genetics and Evolution)

SECTION- A

Q1. Answer

i.) c ii) c iii) b iv) c v) b vi) c vii) b viii) c ix) c x) c

SECTION-B

Q2. Answer

The laws of inheritance were derived by Gregor Mendel, conducting hybridization experiments in garden peas (*Pisum sativum*). From these experiments, he induced two generalizations which later became known as Mendel's Principles of Heredity or Mendelian inheritance.

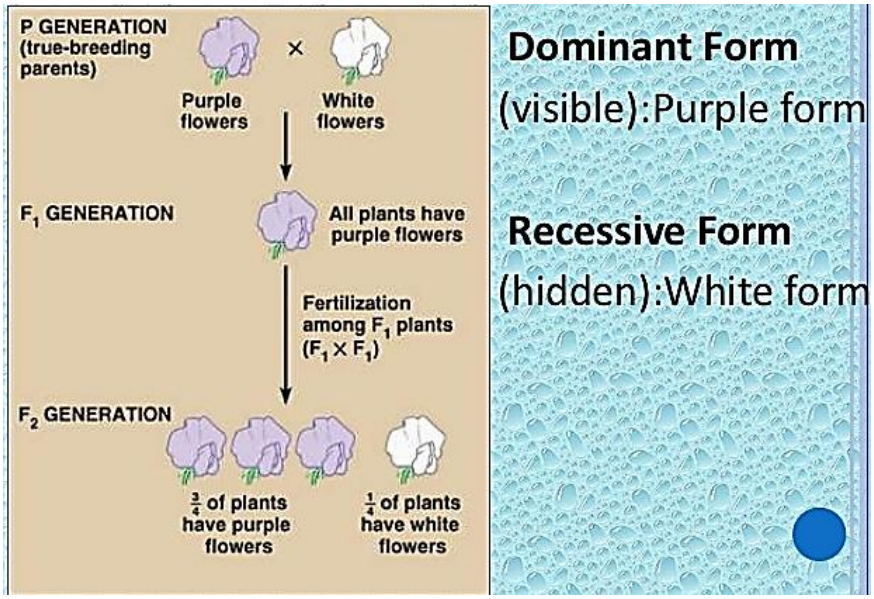
Mendelian inheritance is inheritance of biological features that follows the laws proposed by Gregor Johann Mendel in 1865 and 1866 and re-discovered in 1900. When Mendel's theories were integrated with the Boveri–Sutton chromosome theory of inheritance by Thomas Hunt Morgan in 1915, they became the core of classical genetics.

Mendel's Laws are as follows:

i). Law of Dominance/ Phenomenon of dominance

Mendel's Law of Dominance states that recessive alleles will always be masked by dominant alleles. Therefore, a cross between a homozygous dominant and a homozygous recessive will always express the dominant phenotype, while still having a heterozygous genotype.

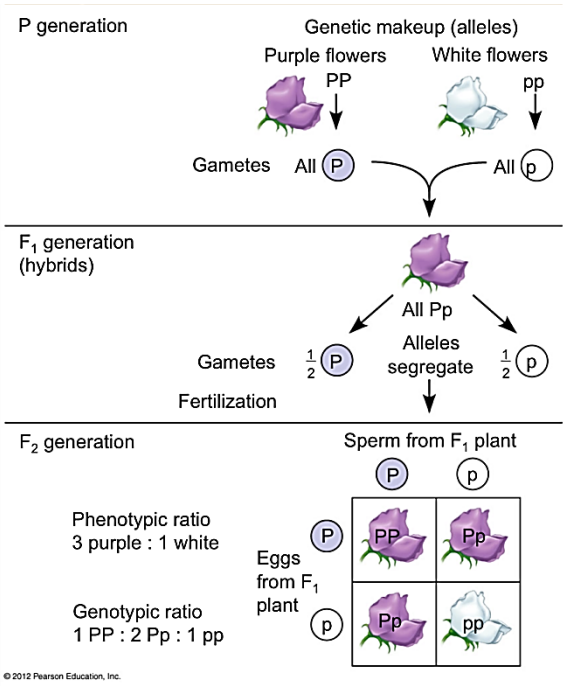
Example: In garden peas the purple colour show the dominant trait.



ii). Law of Segregation

During the formation of gametes (eggs or sperm), the two alleles responsible for a trait separate from each other. Alleles for a trait are then "recombined" at fertilization, producing the genotype for the traits of the offspring.

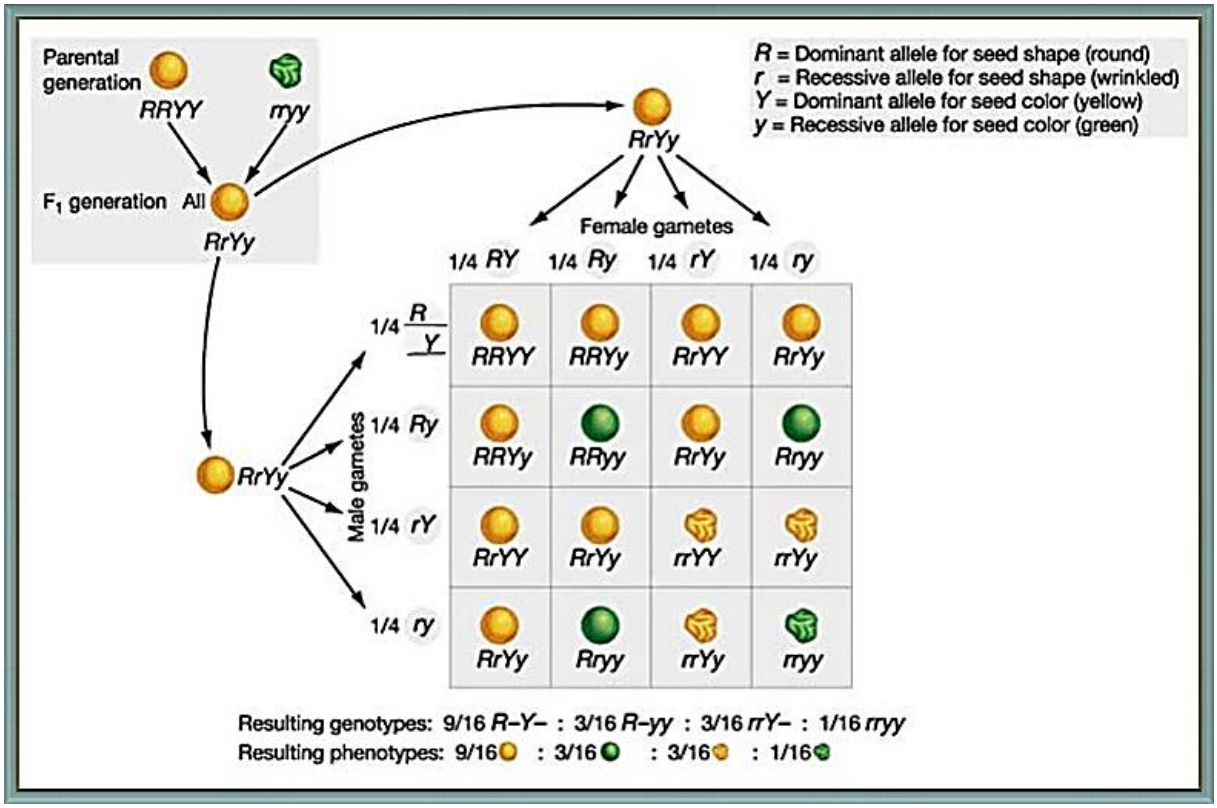
Example: In garden peas the colour of flower is inherited accordingly the law of segregation.



iii). Law of Independent Assortment

Alleles for different traits are distributed to sex cells (& offspring) independently of one another.Means genes for different traits can segregate independently during the formation of gametes.

Example: In garden peas the shape of seed are inherited accordingly the law of independent assortment.



Q3. Answer

Linkage is the tendency of alleles that are located close together on a chromosome to be inherited together during the meiosis phase of sexual reproduction. Genes whose loci are nearer to each other are less likely to be separated onto different chromatids during chromosomal crossover, and are therefore said to be genetically *linked*.

Linked genes are those genes which occur on the same chromosome while unlinked genes are the ones found on different chromosomes. Linked and unlinked genes can be easily known from breeding experiments. Unlinked genes show independent assortment, a di-hybrid ratio of 9: 3: 3: 1 and the di-hybrid or double test cross ratio of 1: 1: 1: 1 with two parental and two recombinant types.The linked genes do not show independent assortment but remain together. They give a test cross ratio of 1: 1.

Linkage is of two types, complete and incomplete.

i). *Complete Linkage:*

The genes located on the same chromosome do not separate and are inherited together over the generations due to the absence of crossing over. Complete linkage allows the combination of parental traits to be inherited as such. It is rare but has been reported in male Drosophila and some other heterogametic organisms.

Example: A red eyed normal winged (wild type) pure breeding female Drosophila is crossed to homozygous recessive purple eyed and vestigial winged male. The progeny or F1 generation individuals are heterozygous red eyed and normal winged. When F1 males are test crossed to homozygous recessive female (purple eyed and vestigial winged), only two types of individuals are produced- red eyed normal winged and purple eye vestigial winged in the ratio of 1 : 1 (parental phenotypes only). Similarly during inbreeding of F1 individuals, recombinant types are absent. In practice, this 1: 1 test ratio is never achieved because total linkage is rare.

ii. *Incomplete Linkage:*

Genes present in the same chromosome have a tendency to separate due to crossing over and hence produce recombinant progeny besides the parental type. The number of recombinant individuals is usually less than the number expected in independent assortment. In independent assortment all the four types (two parental types and two recombinant types) are each 25%. In case of linkage, each of the two parental types is more than 25% while each of the recombinant types is less than 25%.

Example: A red eyed normal winged or wild type dominant homozygous female Drosophila is crossed to homozygous recessive purple eyed and vestigial winged male. The progeny or F_1 individuals are heterozygous red eyed and normal winged. F_1 female flies are test crossed with homozygous recessive males. It does not yield the ratio of 1: 1: 1: 1. Instead the ratio comes out to be 9: 1: 1: 8. This shows that the two genes did not segregate independently of each other.

Linkage vs Crossing Over

Linkage

1. It is tendency of genes on a chromosome to remain together and passed as such in next generation.
2. It brings more parental types.
3. Strength of linkage between two genes increases if they are closely placed on a chromosome.
4. With increase in age, link age increases
5. It helps to maintain a newly improved variety.

Crossing Over

1. It is exchange of genes or chromosomal parts to break established linkages and formation of new linkages.
2. It produces recombinations.
3. Frequency of crossing over between two genes decreases if they are closely placed.
4. Crossing over decreases.
5. It is the source of variations for producing new varieties.

Q.4 Answer

A karyotype is the number and appearance of chromosomes in the nucleus of an eukaryotic cell. Karyotypes describe the chromosome count of an organism, and what these chromosomes look like under a light microscope. Attention is paid to their length, the position of the centromeres, banding pattern, any differences between the sex chromosomes, and any other physical characteristics. The preparation and study of karyotypes is part of cytogenetics.

Six different characteristics of karyotypes are usually observed and compared:

1. Differences in absolute sizes of chromosomes.
2. Differences in the position of centromeres.
3. Differences in relative size of chromosomes.
4. Differences in basic number of chromosomes.
5. Differences in number and position of satellites.
6. Differences in degree and distribution of heterochromatic regions.

Types of banding

There are several techniques to visualize different aspects of chromosomes.

1. **G-banding** is obtained with Giemsa stain following digestion of chromosomes with trypsin. It yields a series of lightly and darkly stained bands - the dark regions tend to be heterochromatic, late-replicating and AT rich.
2. **R-banding** is the reverse of G-banding (the R stands for "reverse"). The dark regions are euchromatic (guanine-cytosine rich regions) and the bright regions are heterochromatic (thymine-adenine rich regions).

3. **C-banding:** Giemsa binds to constitutive heterochromatin, so it stains centromeres.The name is derived from centromeric or constitutive heterochromatin.
4. **Q-banding:** is a fluorescent pattern obtained using quinacrine for staining. The pattern of bands is very similar to that seen in G-banding.Quinacrin (atebrin) binds both regions rich in AT and in GC, but only the AT-quinacrin-complex fluoresces.
5. **T-banding:** visualize telomeres.
6. **Silver staining:** Silver nitrate stains the nucleolar organization region-associated protein.

Types of karyotyping

Classic karyotyping

In the "classic" karyotype, a dye, often Giemsa *(G-banding),* less frequently Quinacrine, is used to stain bands on the chromosomes. Giemsa is specific for the phosphate groups of DNA. Quinacrine binds to the adenine-thymine-rich regions. Each chromosome has a characteristic banding pattern that helps to identify them; both chromosomes in a pair will have the same banding pattern.

Spectral karyotyping

Spectral karyotyping is a molecular cytogenetic technique used to simultaneously visualize all the pairs of chromosomes in an organism in different colors. Fluorescently labeled probes for each chromosome are made by labeling chromosome-specific DNA with different fluorophores. Because there are a limited number of spectrally distinct fluorophores, a combinatorial labeling method is used to generate many different colors.

This technique is used to identify structural chromosome aberrations in cancer cells and other disease conditions when Giemsa banding or other techniques are not accurate enough.

Digital karyotyping

Digital karyotyping is a technique used to quantify the DNA copy number on a genomic scale. Short sequences of DNA from specific loci all over the genome are isolated and enumerated. This method is also known as virtual karyotyping.

Q5. Answer

Evolution and its features

Gradual changing of living organisms from simple to complex (i.e. from imperfect to perfect) is called evolution.

It is change in heritable traits of biological populations over successive generations. Evolutionary processes give rise to diversity at every level of biological organisation, including the levels of species, individual organisms, and molecules.

Features of Evolution:

- ✓ It is slow gradual and continuous process
- ✓ It is natural occurring process
- ✓ It is irreversible process
- ✓ Simple organisms modify into complex one
- ✓ Evolution takes place in any direction
- ✓ Variation exists because heredity is not perfect. Variation arises primarily through random mutations and recombination.
- ✓ All evolutionary changes depend upon changes *within populations*. These consist of alterations of the proportions of the genotypes, hence the genes (alleles), borne by the individual organisms that make up the population.
- ✓ Allele frequencies remain constant unless forces change them. Factors that may alter allele frequencies in a population include: mutation, genetic drift and gene flow.
- ✓ Another factor that may alter allele frequencies in a population is natural selection (which is defined as differential survival and differential reproduction of genotypes).
- ✓ Evolution proceeds at different rates
- ✓ Many mutations are advantageous in some contexts, disadvantageous in others, or neutral. The advantage of an allele or genotype depends upon the environment.
- ✓ The chance (probability) that a mutation will occur is not affected by the advantage or disadvantage it confers.
- ✓ Organisms cannot evolve adaptations in anticipation of future events nor do adaptations evolve for the "good of the species".

- ✓ Not all characteristics evolved because they were adaptive.
- ✓ Speciation generally requires barriers to gene flow.
- ✓ If gene flow among local populations of a species is sufficiently restricted, the populations may so diverge that they will not or cannot interbreed. That is, speciation occurs.
- ✓ If two populations have become different species, the genetic changes in one are usually not transmitted to the other, so they pursue independent evolutionary paths.
- ✓ The principles of intraspecific evolution apply to all genetically controlled characters and at all taxonomic levels.

Q6. Answer

Lamarckism: ***The Inheritance of Acquired Characteristics***

- ✓ A changing environment creates a need for certain features to be developed in order to survive.
- ✓ "Acquired Characteristics": Through use and/or non-use, those features needed for survival are developed in each individual.
- ✓ Inheritance: Those characteristics developed ("acquired") by individuals are somehow passed on to their offspring, who can continue that development.
- ✓ New Species: Eventually, over many generations, enough differences have developed that we can say we have a new species.

Darwinism : ***Natural Selection***

- ✓ Overproduction: More offspring produced than will ultimately survive and reproduce
- ✓ Variation: Inheritable features vary from individual to individual.
- ✓ Change in environment: Changes in climate, topography, food supply, predators, etc.
- ✓ "Struggle for existence": Mainly competition within the species, for food, habitat, survival from being eaten
- ✓ "Survival of the fit" (not necessarily the strongest): Those with more adaptive traits tend to survive longer and/or produce the most offspring; these are the "naturally selected".
- ✓ Inheritance of "selected" features: Traits involved are already inheritable, but may involve new combinations.
- ✓ New Species, better adapted to the new environment: When the collective traits of the population differ significantly from the earlier population, and can no longer reproduce with the earlier population

Q.7. Evolutionary biology includes both the origin of life and the diversity of living organisms on the earth. Various concepts explain the process of evolution, but the important concepts or theories that explain the scientific basis of organic evolution are Lamarckism, Darwinism, Mutation theory and modern synthesis theory.

- ✓ Special creation theory (By Suraze): A/to this theory life was created by supernatural power like God

  A/to Bibil, the universe was created within six days-

  On Ist days –Earth and heaven

  On IInd days- Sky

  On IIIrd days-Land

  On IVth days-Sun Moon & Stars

  On Vth days-Fertile plant, fishes, birds

  On VIth days-Human

  First man was Adam and first woman was Eve

  A/to Hindu mythology universe was created by Brahma, First man was Manu and first woman was Shradha

- ✓ ***Spontaneous creation theory*** (Abiogenesis theory given by Thales, Anaximander, Plato, Aristotle): A/to this theory life was created from non living things in spontaneous manner. Ancient Egyptian believed that mud of Nil river could give rise to crocodile, frog, fishes, snakes etc.

  Helmolt held that cloth and grains give rise to organism This theory was experimentally rejected by F. Redi

- ✓ ***Biogenesis Theory*** –Given by F. Redi and supported by Spllanzani & L. Pasture, A/to this theory life was created from pre-existing life, This theory does not give idea about origin of first life so it is also rejected.

- ✓ Cosmozoic (Panspermia) Theory-Given by Richter, A/to this theory "Protoplasm" reached the earth in the form of "Spore or germs or other simple particles" from some unknown part of the Universe with cosmic dust and subsequently evolved into various forms of life.

- ✓ ***Modern theory*** given by a (Russian) Scientist A.I Oparin in his book "Origin of Life" (1936). It is most accepted theory. It may be studied in the following trend: Origin of Earth & Life (Cells). It is consider that the age of earth is about 4600 million years. It

is understood that the sun and its planets were formed from clouds of cosmic gases and dust began to condense into compact mass. Due to this reason thermonuclear reaction initiated and extra heat and pressure produced. Most compacted mass converted into Sun and remainder into planets (MVEMJSUN) and several satellites. At that time temperature of earth was 6000°C.

Organic/chemical evolution had taken in following phases:

- ✓ **Free atom phase**-Na, K, Fe, Ni.. Si, Al, Co, C H O N etc.
- ✓ **Formation of first molecule**-water and ammonia
- ✓ **Formation of first organic compound**-Methane
- ✓ **Formation of micro molecules-** amino acid, sugar, fatty acid, glycerol nitrogenous bases etc.
- ✓ **Formation of macro molecules** -Protein, Starch, Fat , Nucleic acid etc.

MUTATION THEORY:

Mutation is a **sudden, random, discontinuous and heritable change** independent of the environment in the genetic make up of an individual. The term mutation was coined by Hugo de Vries, a dutch botanist in 1901. Darwin called such variations as sports where as Bateson called them discontinuous variations. Hugo de Vries observed evening primose *Oenothera lamarckiana,* which is a biennial plant of 5 to 6' height. The wild variety showed different characteristics in different forms *O. brevistylis* -small style, *O. levifolia* -smooth leaves, *O, gigas* -the giant form, *O, nanella* -the dwarf form etc. These characters are inherited to the progeny.Each of them is called mutant and the characteristics are called mutations. Mutation is the whole truth of evolution to Hugo de Vries, who proposed mutation theory. It states that new full-fledged species originate at once as a result of large, discontinuous variations which appear suddenly

The modern theory of evolution includes both Darwin’s ideas of variation and natural selection and the current knowledge of the sources of variations.

Q.8 Answer

According to Darwin during the struggle for existence, the organisms with beneficial variations alone will survive. Darwin hypothesised that these variations are sorted out by nature through competition. The organisms which are selected by nature are said to be the fittest. This idea of **survival of the fittest** was proposed by **Herbert Spencer**. Variations which are useful to the individual in a particular environment would increase that individual's ability to reproduce and leave fertile offspring. These are favoured by nature. Less favourable variations would be at disadvantage and organisms possessing them are reproductively less successful. Differential reproductive success exists among organisms. The concept of differential reproductive success of various forms is more accurate. Over period of time, the criterion for the success is the reproductive success. The organism that fails to reproduce cannot be represented in future generations however fit it may be in the struggle for existence.

Example : Industrial melanism:

A classical example of natural selection in the case of peppered grey moth *Biston betularia* which was abundant before industrial revolution all over England. These moths showed colouration with two phenotypes, grey and black. The black forms were more and grey forms were less in the industrial period particularly in the industrial cities like Birmingham. This change in the population of peppered moth was due to the pollution caused by the industrial revolution. Prior to industrial revolution the grey moths succeeded to camouflage the light trunks of the trees. With the industrial revolution more soot was released due to the burning of coal. Tree barks became black. Grey moths were easily identified and were more predated by the birds. Grey moths decreased in number and dark moths increased in the population.

Therefore natural selection favoured the melanic moths to reproduce more successfully.

Natural selection of darker forms in response to industrial pollution is known as industrial melanism